

**ANNEX
BETWEEN
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER
AND
AMERICAN AIRLINES, INC.
UNDER SPACE ACT UMBRELLA AGREEMENT NO. 32294, SAA2-403551
(ANNEX NUMBER ONE)**

ARTICLE 1. PURPOSE

This Annex 1 (the “Annex”) is entered into by and between the National Aeronautics and Space Administration Ames Research Center (“NASA”) and American Airlines, Inc. (“American Airlines”) pursuant to that certain Nonreimbursable Space Act Umbrella Agreement, by and between NASA and American Airlines (the “Agreement”). This Annex is part of the Agreement and shall be subject to the terms and conditions contained therein. Capitalized terms used herein and not otherwise defined in this Annex shall have the meanings ascribed to such terms in the Agreement. This Annex shall be for the purpose of enabling collaboration between NASA System-Wide Safety (“SWS”) researchers and American Airlines to share safety critical flight and ground operations data to be integrated with, and processed by, risk precursor detection algorithms. American Airlines has the capabilities to provide high-fidelity flight and ground operations data obtained from their day to day operations in the national airspace (“NAS”). Examples of this data may include de-identified flight and ground data (both operational and derived). NASA SWS has the capabilities to provide information and tools about risk analysis and prognostics. Examples may include open-source or other NASA-developed tools (under appropriate Software Usage Agreements) for safety analysis, prognostics algorithms and development best practices, full or partial safety use cases, and access to safety scientists and engineers.

The collaborative efforts between NASA and American Airlines will result in the demonstration of an initial proof-of-concept dashboard that shows an integration of NASA and Airline Operations Center (AOC)/AA’s Fort Worth, Texas Integrated Operations Center (IOC) developed precursor detection capabilities. This dashboard will demonstrate NASA’s precursor analysis given risk over multiple adverse events benefiting the U.S. aviation industry at large.

The legal authority for this Annex, consistent with the Umbrella Agreement, is in accordance with the National Aeronautics and Space Act (51 U.S.C. § 20113(e)).

ARTICLE 2. RESPONSIBILITIES

A. NASA ARC will use reasonable efforts to:

Year One:

1. Review American Airlines’ FOQA, ASAP and LOSA data repositories, data types and constraints, top hazards, and overall safety process.

2. Identify appropriate algorithms for the analysis of anonymized and de-identified American Airlines' FOQA, ASAP and LOSA data for a calendar year selected by American Airlines (collectively with any other American Airlines data that American Airlines agrees to provide NASA, "American Data"), given the data types and constraints.
3. Note any technical gaps regarding data quality or fusion that prevent the use of existing algorithms.

Year Two:

1. Merge and preprocess American Data streams as necessary for the use of algorithms created by NASA.
2. Apply algorithms created by NASA that find precursors to hazards given time-series Data as instructed by Partner. The algorithms utilized will be run on AA servers, and the resulting analyses will be generated and remain on AA servers.
3. Apply algorithms created by NASA that find anomalous behavior as instructed by Partner. The algorithms utilized will be run on AA servers, and the resulting analyses will be generated and remain on AA servers.

Year Three:

1. Apply algorithms that monitor for and assess risk on integrated American Data streams as instructed by Partner. The target is to demonstrate an in-time safety analysis capability that could be used by an Airlines Operation Center to evaluate and lower risk. The algorithms utilized will be run on AA servers, and the resulting analyses will be generated and remain on AA servers.

B. Partner will use reasonable efforts to:

Year One:

1. Provide NASA access to safety process experts and American Data repository owners.
2. Provide NASA with access to subject matter experts for hazard analysis and risk assessment over anomalous American Data. Such subject matter experts shall instruct NASA on areas of focus.
3. Provide NASA with access to American Airlines' owned flight, ground, and maintenance American Data sources. These American Data sources may be historical or current.

Year Two:

1. Provide NASA with access to American Airlines' owned flight, ground, and maintenance American Data sources. These American Data sources may be historical or current.
2. Provide NASA with access to subject matter experts for the evaluation and explanation of algorithm results.

Year Three:

1. Provide NASA with access to American Airlines' owned flight, ground, and maintenance American Data sources. At least some of the American Data should be current enough to allow for detection of risk in time to mitigate the risk before a hazard is realized.
2. Continue to provide access to subject matter experts for the evaluation and explanation of overall capability results.

C. Both Parties will use reasonable efforts to:

Year One:

1. Identify key hazards and system-level risks that have the potential for automatic discovery.
2. Identify necessary American Data products that would allow for this automated discovery and identify any restrictions or protections for the American Data.
3. Prototype initial integration of NASA algorithms with American Data.

Year Two:

1. Expand the integration of NASA algorithms with American Data to include merging American Data sources (e.g. FOQA, ASAP and LOSA and ground operations or maintenance Data).
2. Design and evaluate safety metrics for understanding overall levels of risk and safety.

Year Three:

1. Demonstrate a prototype In-Time System-Wide Safety Assurance capability that can assess risk and alert safety operators to the need for mitigation.
2. Evaluate the demonstration of the In-Time System-Wide Safety Analysis proof-of-concept.
3. Jointly publish appropriate and non-proprietary findings.

ARTICLE 3. SCHEDULE AND MILESTONES

The Parties will use reasonable efforts to achieve the planned major milestones for the activities for this Annex defined in the "Responsibilities" Article and set forth in the table below:

Milestones	Estimated completion Date
American Airlines to provide NASA with access to safety process experts and American Data repository owners as well as subject matter expertise for hazard analysis and risk assessment over anomalous American Data, including access to American Airlines' owned flight, ground, and maintenance historical or current American Data sources. (Partner)	May 2021

NASA to review American Data repositories, American Data types and constraints, top hazards, and overall safety process; identify appropriate algorithms for the analysis of American Data, given the data types and constraints; note any technical gaps. (NASA)	May 2021
Identify key hazards and system-level risks that have the potential for automatic discovery and necessary American Data products that would allow for this automated discovery including any restrictions or protections for the American Data; prototype initial integration of NASA algorithms with American Data. (Joint)	May 2021
American Airlines to provide NASA with access to American Airlines' owned flight, ground, and maintenance historical or current American Data sources as well as subject matter expertise for the evaluation and explanation of algorithm results. (Partner)	May 2022
Merge and preprocess American Data streams as necessary for the use of the algorithms; apply algorithms that find precursors to hazards given time-series American Data including algorithms that find anomalous behavior. (NASA)	May 2022
Expand the integration of NASA algorithms with American Data to include merging Data sources (e.g. FOQA and ground operations or maintenance Data) and design and evaluate safety metrics for understanding overall levels of risk and safety. (Joint)	May 2022
American Airlines to provide NASA with access to American Airlines' owned flight, ground, and maintenance American Data sources ensuring some of the American Data is current enough to allow for detection of risk in time to mitigate the risk before a hazard is realized and continue to provide subject matter expertise for the evaluation and explanation of overall capability results. (Partner)	May 2023
Apply algorithms that monitor for and assess risk on integrated American Data streams. The target is to demonstrate an in-time safety analysis capability that could be used by an Airlines Operation Center to evaluate and lower risk. (NASA)	May 2023
Demonstrate a prototype In-Time System-Wide Safety Assurance capability that can assess risk and alert safety operators to the need for mitigation and evaluate the demonstration of the In-Time System-Wide Safety Analysis proof-of-concept. (Joint)	May 2023
Publish appropriate and non-proprietary findings. (Joint)	May 2023

ARTICLE 4. FINANCIAL OBLIGATIONS

There will be no transfer of funds between the Parties under this Agreement and each Party will fund its own participation. All activities under or pursuant to this Agreement are subject to the

availability of funds, and no provision of this Agreement shall be interpreted to require obligation or payment of funds in violation of the Anti-Deficiency Act (31 U.S.C. § 1341).

ARTICLE 5. INTELLECTUAL PROPERTY RIGHTS - DATA RIGHTS

A. Data produced under this Annex which is subject to paragraph C. of the Intellectual Property Rights - Data Rights Article of the Umbrella Agreement will be protected for the period of three (3) years.

B. Under paragraph I. of the Intellectual Property Rights - Data Rights Article of the Umbrella Agreement, Disclosing Party provides the following Data to Receiving Party. The lists below may not be comprehensive, are subject to change, and do not supersede any restrictive notice on the Data provided.

1. Background Data:

The Disclosing Party's Background Data, if any, will be identified in a separate document.

2. Third Party Proprietary Data:

The Disclosing Party's Third-Party Proprietary Data, if any, will be identified in a separate document.

3. Controlled Government Data:

The Disclosing Party's Controlled Government Data, if any, will be identified in a separate document.

4. The following software and related Data will be provided to Partner under a separate Software Usage Agreement: None.

C. NASA shall only access American Airlines Proprietary Data (as defined in Paragraph D) with American Airlines-provided access credentials to a virtual private network connected to an American Airlines' server, both of which will be designated by American Airlines in its sole discretion. NASA shall perform any obligations in connection with this Annex only on American Airlines' designated server, and shall not mirror, reproduce, download or otherwise copy such Data onto any NASA-owned or operated hardware. NASA will use American Airlines Proprietary Data as instructed by Partner. Further, NASA must notify American Airlines within twenty-four (24) hours of becoming aware of any actual or suspected loss, unauthorized disclosure, or unauthorized use of or access to any access credentials to American Airlines' designated virtual private network and/or server.

NASA ARC will be using the existing algorithms that are open sourced under ARC-16462-1A: Multiple Kernel Anomaly Detection (MKAD) Algorithm Python Version and ARC-18198-1: Automatic Discovery of Precursors in Time Series Data (ADOPT)

D. American Airlines Proprietary Data: The Parties agree that the following American Data is proprietary:

All flight, ground, and maintenance (historical or current) American Data provided by or received from Partner.

All FOQA, ASAP and LOSA data and safety reports provided by or received from Partner.

For the avoidance of doubt, Article 11(D) of the Agreement shall apply in all respects to all American Airlines Proprietary Data received from Partner under this Annex.

ARTICLE 6. TERM OF ANNEX

This Annex becomes effective upon the date of the last signature below ("Effective Date") and shall remain in effect until the completion of all obligations of both Parties hereto, or three years from the Effective Date, whichever comes first, unless such term exceeds the duration of the Umbrella Agreement. The term of this Annex shall not exceed the term of the Umbrella Agreement. The Annex automatically expires upon the expiration of the Umbrella Agreement.

ARTICLE 7. RIGHT TO TERMINATE

Either Party may unilaterally terminate this Annex by providing thirty (30) calendar days written notice to the other Party.

ARTICLE 8. POINTS OF CONTACT

The following personnel are designated as the Points of Contact between the Parties in the performance of this Annex.

Management Points of Contact

NASA Ames Research Center

Matthew J. Holtrust
Agreement Manager
Mail Stop: 223-3, Room 100
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American Airlines

Captain Ronald Thomas
Vice President – Safety,
Environmental & Regulatory
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Technical Points of Contact

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ARTICLE 9. MODIFICATIONS

Any modification to this Annex shall be executed, in writing, and signed by an authorized representative of NASA and the Partner. Modification of an Annex does not modify the terms of the Umbrella Agreement.

ARTICLE 10. SIGNATORY AUTHORITY

The signatories to this Annex covenant and warrant that they have authority to execute this Annex. By signing below, the undersigned agrees to the above terms and conditions.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AMES RESEARCH CENTER

BY: _____
Dr. Rupak Biswas
Director of Exploration Technology

DATE: _____

AMERICAN AIRLINES, INC.

BY: Ronald G. Thomas
Captain Ronald Thomas
Vice President – Safety, Environmental
& Regulatory Compliance

DATE: 2/19/2021